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A Comparative Analysis of Land Surface Retrieval Methods Using Landsat 7 and 8 Data to Study Urban Heat Island Effect in Madurai

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Abstract: In this paper the urban heat islands (UHI) effect in Madurai region has been identified by retrieving the land surface temperature (LST) distribution.The aim of this paper is to implement an algorithm to measure land surface temperature in Madurai region and it's surrounding from Landsat thermal imagery. The Land surface temperature has been estimated by using Single Channel (SC) algorithm and Split-Window (SW) algorithm. These two algorithms can be implemented using Landsat 7 and Landsat 8 satellite data. The various methods adopted for retrieving the algorithm has been addressed in the present study. The results show that for Single Channel (SC) algorithm the error is approximately 1K-2K and in Split-Window (SW) algorithm the error is reduced becauseas SW algorithm uses two Thermal Infrared (TIR) bands for land surface temperature retrieval. In SW algorithm error is less than 1K. The results show that the LST generated using the SW algorithm was more reliable and accurate. From the final output it is revealed that barren lands, uncultivable land and urban areas experienced high LST and the areas with high vegetation cover and water body experiencing low LST. The results from both the algorithms show a variance of 5-6^{o}C between urban areas, barren lands and vegetation covers thus indicating the presence of UHI in Madurai city.

***Keywords:** Landsat, Land Surface Temperature (LST), Single Channel (SC) algorithm, Split Window (SW) algorithm, Thermal infrared (TIR), Normalized Difference Vegetation Index (NDVI)*

1. Introduction

The urban air temperature is gradually rising in all cities in the world. One of the possible causes is the drastic reduction in the greenery area in cities. The distinguished climatic condition termed 'Urban Heat Island' (UHI) is developing in the rapidly urbanized cities. Madurai is also experiencing rapid urbanization that has resulted in remarkable UHI. Appropriate measurements of Land Surface Temperature (LST) are useful for urban climate studies due to its important role in the surface energy budget (Lucena et.al. 2013). The rising population and industrialization leads to changes in the land use and land cover patterns, thereby leading to a rise in land surface temperature. So it is essential to monitor LST in the urban areas. The traditional method to obtain LST is a measurement at fixed observation time and location by a thermometer. Due to the variable changes of LST, the method of discrete point measurement cannot obtain large-scale and continuous LST information. However, the development of satellite thermal infrared remote sensing technology makes it possible to get the LST distribution over large regions with a regular revisit capability (Yang et al., 2014). The retrieval of land surface temperature (LST) from high to medium spatial resolution remote sensing data is important, as it is useful for many environmental studies. Land Surface Temperature (LST) is also an important phenomenon in global climate change, as the increase in greenhouse gases in the atmosphere will lead to an increase of LST.

The present study estimates land surface temperature by using Single Channel (SC) algorithm and Split-Window (SW) algorithm. The prime focus of this research is to identify the appropriate method to estimate the land surface temperature from Landsat thermal imagery. The two algorithms can be implemented using Landsat 7 and Landsat 8 satellite data. The various methods adopted for retrieving the algorithm has been addressed in this study. The results show that for Single Channel (SC) algorithm the error is approximately 1K-2K and in Split-Window (SW) algorithm the error is less than 1K because in SW algorithm two Thermal Infrared (TIR)) bands are used for land surface temperature retrieval. From the final output it is revealed that barren lands, uncultivable land and urban areas experienced high LST and the areas with high vegetation cover and water body experiencing low land surface temperature. Urban heat island phenomenon is evident from the LST images.

1.1 Study Area

Madurai is the third largest city in the Indian state of Tamil Nadu and one of the oldest continuously inhabited cities. It is known as the Athens of the east, and is one of the ancient historic cities in the world. The archeological findings clearly suggest that the city is more than 2500 years old.

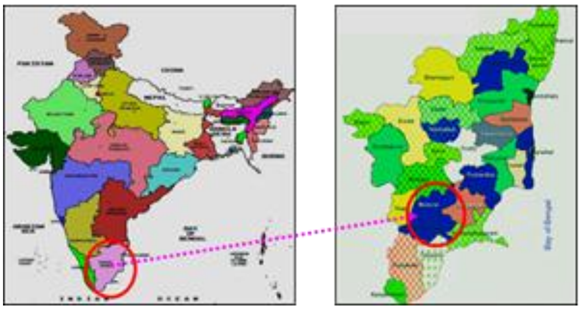

Fig 1: *Geographical location of Madurai*

Madurai is located at 9.93°N 78.12°E. Madurai city is situated at a distance of 498 kilometers (309 mi) south-west of Chennai, the capital of Tamil Nadu. Figure 1 shows the location of Madurai in Tamil Nadu. It has an average elevation of 101 meters. The municipal corporation of Madurai has an area of 52 km^{2}and an overall population of 3,041,038 (Census 2011).

1.2 Climate of Madurai

Madurai experiences tropical climate. The summers are much hotter than the winters in Madurai. The climate of Madurai is classified as warm and humid by Köppen and Geiger. In Madurai, the average annual temperature is 28.8 °C, with an average annual rainfall of 840 mm. Temperatures during summer generally reach a maximum of 40 °C and a minimum of 26.3 °C, although temperatures up to 42 °C are not uncommon. Winter temperatures range between 29.6 °C and 18 °C. Table 1 show the climatic data of Madurai for the period 1971 to 2000.The average maximum temperature recorded is 37.7ºC in the month of May (Table 1). An average maximum temperature of 40 °C for the decade of 2002 – 2013 is shown in Figure 2. A study based on the data available with the Indian Meteorological Department on Madurai over a period of 62 years indicate rising trend in atmospheric temperature over Madurai city, attributed to urbanization, growth of vehicles and industrial activity.

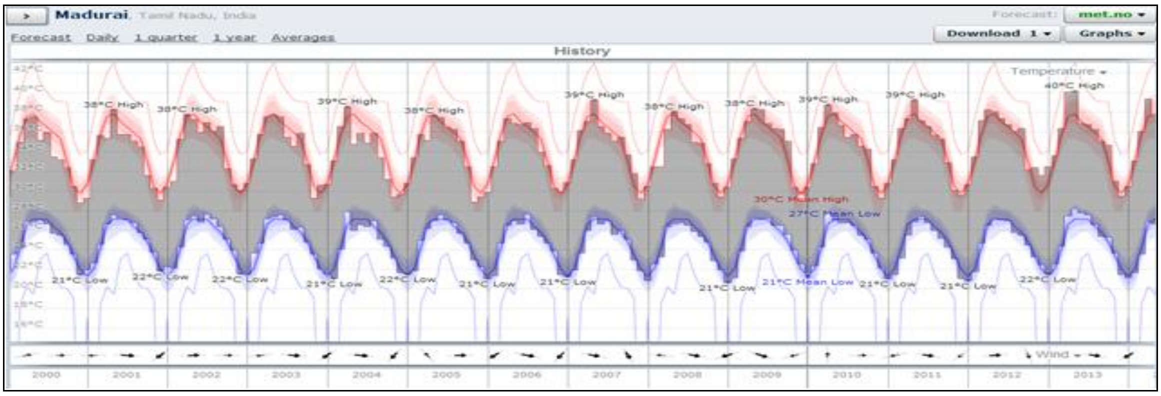

Fig 2: *Temperature data for Madurai, India (2000-2013)*

Table 1: *Climate data for Madurai, India (1971-2000)*

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high, °C (°F)	39.1 (102.4)	38.5 (101.3)	41.7 (107.1)	42.1 (107.8)	44.5 (112.1)	42.2 (108)	40.6 (105.1)	40.0 (104)	39.8 (103.6)	40.0 (104)	38.0 (100.4)	37.0 (98.6)	44.5 (112.1)
Average high, °C (°F)	30.6 (87.1)	33.2 (91.8)	35.8 (96.4)	37.3 (99.1)	37.7 (99.9)	36.8 (98.2)	36.0 (96.8)	35.7 (96.3)	34.8 (94.6)	32.7 (90.9)	30.6 (87.1)	29.7 (85.5)	34.2 (93.6)
Average low, °C (°F)	20.1 (68.2)	21.1 (70)	23.0 (73.4)	25.4 (77.7)	26.1 (79)	26.1 (79)	25.6 (78.1)	25.3 (77.5)	24.3 (75.7)	23.6 (74.5)	22.6 (72.7)	21.1 (70)	23.7 (74.7)
Record low, °C (°F)	15.6 (60.1)	10.5 (50.9)	16.9 (62.4)	19.4 (66.9)	17.8 (64)	17.8 (64)	19.4 (66.9)	20.6 (69.1)	18.5 (65.3)	18.9 (66)	17.2 (63)	16.7 (62.1)	10.5 (50.9)
Average precipitation, mm (inches)	7.4 (0.291)	11.8 (0.465)	14.1 (0.555)	37.1 (1.461)	72.6 (2.858)	32.0 (1.26)	83.2 (3.276)	80.3 (3.161)	146.9 (5.783)	159.4 (6.276)	140.3 (5.524)	53.0 (2.087)	838.0 (32.992)
Average precipitation days	0.9	1.1	1.1	2.4	4.4	2.0	3.6	4.1	7.8	8.1	6.3	3.4	45.1

1.3 Data and Software Used

The Landsat 7 image (Figure 3) for Madurai district retrieved on September 23, 2014 and Landsat 8(Figure4) retrieved on February 23, 2015 at a moderate resolution of 30m has been used in this study. Landsat 7 has been used to get Thermal Infrared (TIR) band 6 and Landsat 8 has been used to get the two TIR bands 10 and 11 located between 10μm to 12μm to estimate brightness temperature. The district was covered in four tiles. Landsat 8 provides metadata of the bands such as thermal constant, rescaling factor value etc., which can be used for calculating LST algorithm.(when you mention various list a few). The IRS-P6 Medium Resolution Linear Imaging Self-Scanner (LISS-III offering a GSD of 23.5m) image (Figure 5) for

Madurai district was downloaded from www.isrobhuvan.org and has been used to generate Normalized Difference Vegetation Index (NDVI) of the study area. For all the calculations at pixel level of the image, models were developed using MATLAB version 10.

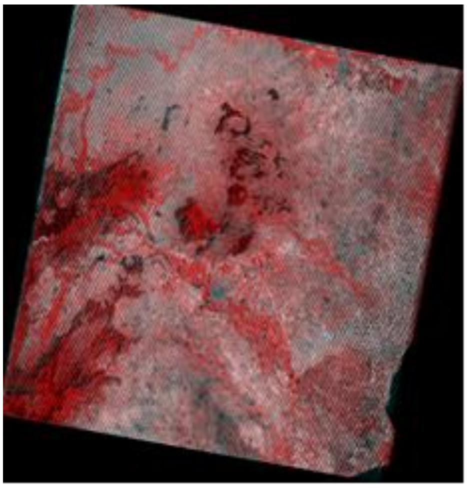

Fig 3: *Original Landsat 7 Image*

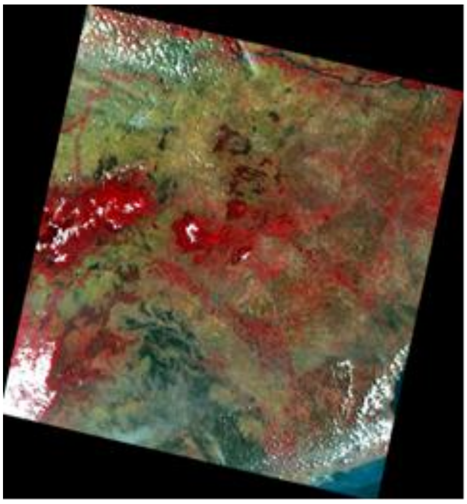

Fig 4: *Original Landsat 8 image*

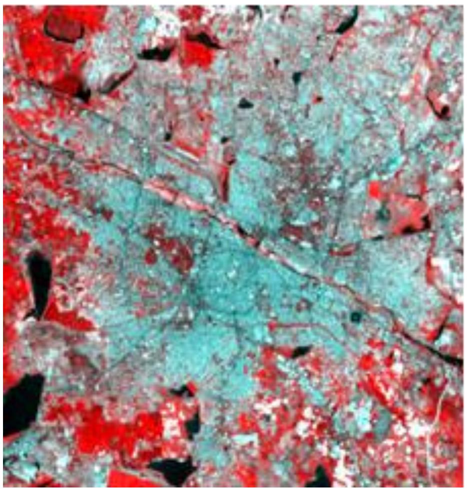

Fig 5: *Subset image- Madurai region*

1.4 Description of Methods

For Madurai region Landsat 7 and Landsat 8 data are used to retrieve LST. Two different algorithms have been used to retrieve LST, the Single Channel (SC) algorithm and Split-Window (SW) algorithm. The prime focus of this research is to identify the appropriate method to estimate the land surface temperature from Landsat thermal imagery. For Single Channel (SC) algorithm only one Thermal Infrared (TIR) band is required so Landsat 7 data was used. In SC algorithm TIR band data is converted into spectral radiance and then spectral radiance is converted into brightness temperature. To retrieve final LST using SC method Land Surface Emissivity (LSE) values are needed. Hence LSE values were retrieved from satellite data by using Normalized Difference Vegetation Index (NDVI) method. The SW algorithm can be only applied to the new Landsat-8 TIRS data since previous TM/ETM sensors had only one TIR band, whereas Landsat 8 has two TIR bands (Jiménez-Muñoz et.al, 2014). The brightness temperature was estimated using TIR bands 10 and 11 of Landsat 8 data. Emissivity was derived by using the same algorithm as in the SC algorithm with the help of NDVI technique for which Operational Land Imager (OLI) bands 2, 3, 4 and 5 were used. The methodology adopted for the two different algorithms is shown in Figures 6 and 7.

2. Single-Channel Algorithm

The methodology for single channel algorithm to be performed for LST retrieval is shown in Figure 6.

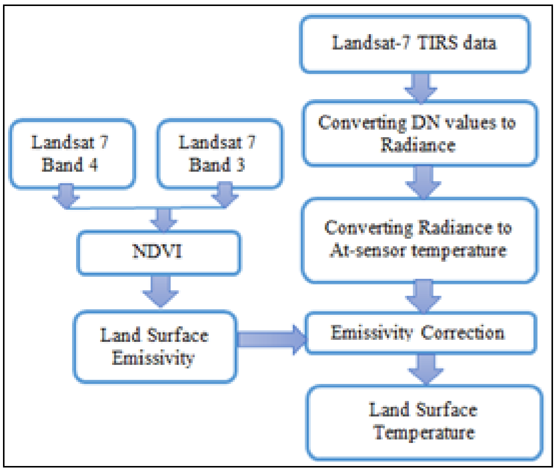

Fig 6: *Flow chart for Single Channel Algorithm*

Landsat7 TIR image is taken. In the image DN values are converted into Radiance value. Then Radiance values are converted into Top of Atmosphere temperature (in kelvin). And then emissivity correction must be done on TOA image using NDVI method to retrieve final LST output.

2.1 Converting DN values to Radiance values

The estimation of land surface temperature using single channel algorithm consists of two basic steps of converting Digital Number (DN) values to radiance and then the estimation of TOA temperature from radiance. The digital number (DN) of thermal infrared band is converted into spectral radiance (L_λ) using the equation (1) supplied by the Landsat 7 science data user's hand book.

$$L_\lambda = \frac{LMAX_\lambda - LMIN_\lambda}{QCALMAX - QCALMIN} * (DN - QCALMIN) + LMIN_\lambda \quad (1)$$

L_λ= Spectral Radiance at the sensor temperature in (watts/meter squared* Ster* μm)
DN = The quantized calibrated pixel value in DN
$LMIN_\lambda$ = The spectral radiance that is scaled to QCALMIN in (watts/meter squared * Ster* μm)
$LMAX_\lambda$ = The spectral radiance that is scaled to QCALMAX in (watts/meter squared * Ster* μm)
$QCALMIN$ =The minimum quantized calibrated pixel value in DN = 1
$QCALMAX$ = The maximum quantized calibrated pixel value in DN = 255

L_{MAX} and L_{MIN} are obtained from the Meta data file available with the Landsat 7/ETM+ image and are given in Table 2.

Table 2: *Band 6 specification in different gain*

Band No.	Satellite/Sensor	LMAX	LMIN
6	Landsat 7/ETM+ High Gain	12.65	3.2
6	Landsat 7/ETM+ Low Gain	17.04	0.0

Spectral radiance can also be calculated using equation 2.

$$L_\lambda = \text{gain*DN + offset} \quad (2)$$

Where L_λ is at sensor radiance, gain is slope of the radiance/DN conversion function, DN is digital number of a given pixel, and offset is the intercept of the radiance/DN conversion function (Yue et.al, 2007). Gain and offset are obtained from the metadata file included in the image.

2.2 Radiance to Brightness Temperature

Brightness temperature is the microwave radiation radiance traveling upward from the top of Earth's atmosphere.

After converting DN values to Radiance the next step is the conversion of radiance to at-sensor temperature (T_B) or Top of Atmosphere (TOA) temperature (Weng et.al, 2004). This can be done by using the Plank's inverse function given in Equation (3).

$$T_B = \frac{K_2}{\ln(\frac{K_1}{L_\lambda}+1)} \quad (3)$$

T_B = Effective at-satellite temperature (in Kelvin)
L_λ = Spectral radiance in watts / (meter squared *ster * μm)
K_1 = Calibration constant 1
K_2 = Calibration constant 2

The calibration constants K1and K2 was obtained from Landsat data user's manual and given in the Table 3 below.

Table 3: *ETM+ and TM Thermal Band Calibration Constants*

Satellites	Calibration Constant K_1	Calibration Constant K_2
Landsat 7	666.09	1282.71
Landsat 5	607.76	1260.56

2.3 Derivation of NDVI

Since the urban thermal environment is related to the reduction of evapotranspiration from the surface vegetation cover, it is useful to recognize the relationship between surface vegetation cover and water availability. The reason NDVI is related to vegetation is that healthy vegetation reflects very well in the near infrared part of the spectrum (Khali et al, 2002). Green leaves have a reflectance of 20 % or less in the 0.5 to 0.7 range (green to red) and about 60 % in the 0.7 to 1.3 μm ranges (near infrared). The value is then normalized to -1<=NDVI<=1 to partially accounted for differences in illumination and surface slope (Sundara et.al, 2012). NDVI for the city Madurai is computed using the formula:

$$NDVI= \frac{Band\ 4 - Band\ 3}{Band\ 4 + Band\ 3} \quad (4)$$

Where, NIR (band 4) and R (band 3) are near infrared and red part of the optical spectrum.

2.4 Emissivity Retrieval

It is important to retrieve the land surface temperature, and radiant or brightness temperature to be corrected according to the real object properties and Land Surface Emissivity (LSE) can represent this. Land Surface Emissivity (ε) is a proportionality factor that scales blackbody radiance (Plank's law) to predict emitted radiance, and it is the efficiency of transmitting thermal energy across the surface into the atmosphere.

There are three major methods for LSE estimation before LST inversion: classification-based emissivity method (CBEM), NDVI-based emissivity method (NBEM) and day/night temperature-independent spectral-indices (TISI) based method (Xiaolei Yu et.al 2014). In this study, a NDVI thresholds method ($NDVI^{THM}$) was used for LSE estimation from Landsat 8 imagery. LSE can be retrieved from NDVI using various methods out of which NDVI Thresholds Method ($NDVI^{THM}$) shows better performance (Sabrino et.al.2004). This method obtains the emissivity values from the NDVI considering different cases:

(a) NDVI < 0.2

In case (a), the pixel is considered as bare soil and the emissivity is obtained from reflectivity values in the red region.

(b) NDVI>0.5

Pixels with NDVI values higher than 0.5 are considered as fully vegetated, and then a constant value for the emissivity is assumed, typically of 0.99.

(c) 0.2<NDVI<0.5

In case (c), the pixel is composed by a mixture of bare soil and vegetation, and the emissivity is calculated according to the following equation:

$$\varepsilon = 0.004 * P_V + 0.986 \quad (5)$$

Where 0.004 and 0.986 are soil and vegetation emissivity respectively.

Where P_V is the proportion of vegetation and it can be calculated from Equation (6).

$$P_V = \left[\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}\right]^2 \quad (6)$$

In the equation 6 $NDVI_{max}$ and $NDVI_{min}$ are calculated from NDVI histogram.

2.5 LST Calculation using SC algorithm

The final LST can be retrieved from emissivity and TOA temperature by using the following Equation 7 (Choudhary et.al, 2012, Weng et.al 2004)

$$T_S = \frac{T_B}{1 + \left(\lambda * \frac{T_B}{\rho}\right) * \ln \varepsilon} \quad (7)$$

Where, λ is the wavelength of the emitted radiance which is equal to 11.5 µm.

$$\rho = \frac{hc}{\sigma}$$

σ- Stefan Boltzmann's constant which is equal to 5.67 x 10^{-8} Wm^{-2} K^{-4},
h- Plank's constant (6.626 x 10^{-34} J Sec),
c- Velocity of light (2.998 x 10^8 m/sec)
ε- Emissivity value
T_B - Brightness temperature

Landsat 7 ETM+ and Landsat 5 data has only one TIR band so single channel algorithm works well for these. But the Landsat 8 satellite launched inFebruary 2013 has two TIRS bands. The main difference between the new TIRS and previous TM/ETM sensors (apart from differences related to sensor design) is the presence of two TIR bands in the atmospheric window between 10 and 12 µm. The presence of two TIR bands opens the possibility to apply split-window (SW) algorithms instead of single-channel (SC) algorithms for LST retrieval. Landsat-8 TIRS is one of the most accurate thermal infrared sensors with relatively high spatial resolutions at present. It may provide a better measurement of LST on the basis of split-window method (Yang et.al, 2014).

3. Split-Window (SW) Algorithm Method

The basis of this technique is that the radiance attenuation for atmospheric absorption is proportional to the radiance difference of simultaneous measurements at two different wavelengths, each subject to different amounts of atmospheric absorption (Jiménez-Muñoz and Sobrino, 2008).This method uses brightness temperature of two bands of TIR, mean and difference in land surface emissivity for estimating LST of an area.

The split-window algorithm is the most commonly used, given that this algorithm removes the atmospheric effect and obtains the LST from the linear or nonlinear combination of the brightness temperatures of two adjacent channels centered at 11 and 12 µm. The methodology for Split-Window (SW) algorithm to be performed for LST retrieval is shown in Figure 7.

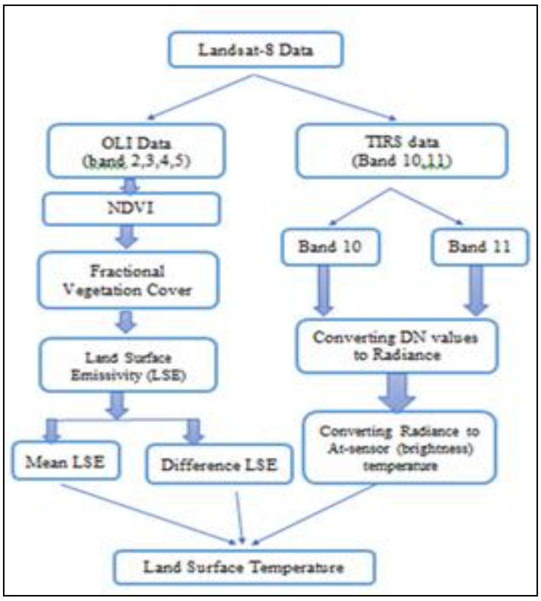

Figure 7: *Flow chart for Split Window Algorithm*

Landsat 8 provides metadata of the bands such as thermal constant (Table 4), rescaling factor value (Table 5).

Table 4: *Thermal constant Band 10 and Band 11*

Thermal Constant	Band 10	Band 11
K_1	774.89	480.89
K_2	1321.08	1201.14

Table 5: *Rescaling Factor Band 10 and Band 11*

Rescaling Factor	Band 10	Band 11
M_L	0.0003342	0.0003342
A_L	0.1	0.1

3.1 SW Coefficient Values Determination

SW coefficients involved in SW equation are calculated after statistical fits (minimization) from a complete simulated database (Jiménez-Muñoz and

Sobrino, 2008). The Split Window Co-efficient for the landsat-8 satellite are given in Table 6.

***Table 6:** Split-window Co-efficient Values*

Constant	Value
C_0	-0.268
C_1	1.378
C_2	0.183
C_3	54.300
C_4	-2.238
C_5	-129.200
C_6	16.400

3.2 Brightness Temperature Calculation

T_B for both the TIRs bands was calculated by adopting the same formula used in SC algorithm given in Equation 2. Here the brightness temperature is calculated for two TIRS bands by using different thermal constants with respect to the specific bands.

3.3 Top of Atmospheric Spectral Radiance Calculation

The value of Top of Atmospheric (TOA) spectral radiance (L_λ) was determined by multiplying multiplicative rescaling factor (0.000342) of TIR bands with its corresponding TIR band and adding additive rescaling factor (0.1) with it. The formula for L_λ is given in Equation 8.

$$L_\lambda = M_L * DN + A_L \qquad (8)$$

Where,

L_λ - Top of Atmospheric radiance in watts/ (m2*srad*µm)
M_L - Band specific multiplicative rescaling factor (radiance_mult_band_10/11)
DN - band 10/ 11 image.
A_L - Band specific additive rescaling factor (radiance_add_band_10/11)

3.4 Land Surface Emissivity (LSE) Retrieval

Knowledge of surface emissivities from remote-sensing data has a major interest as an input for accurate land surface-temperature estimates, particularly for low resolution sensors (Sabrino et.al, 2008) Land Surface Emissivity (ε) is a proportionality factor that scales blackbody radiance (Planck's law) to predict emitted radiance. Thus, ε must be known in order to estimate land surface temperature (LST) accurately (Jiménez-Muñoz and Sobrino, 2008). The next important reason for LSE correction is the fact of possessing only one thermal channel makes it impossible to apply well-known and accepted method.

Estimation of Land Surface Emissivity (LSE) from Fractional Vegetation Cover (FVC) layer can be calculated from the Equation (9).

$$\text{LSE} = \varepsilon_s * (1 - \text{FVC}) + \varepsilon_v * \text{FVC} \qquad (9)$$

Where, ε_s and ε_v - soil and vegetative emissivity values of the corresponding bands given in the Table 7 below.

***Table 7:** Emissivity values in Band 10 and band 11*

Emissivity	Band 10	Band 11
ε_s	0.971	0.977
ε_v	0.987	0.989

The fractional vegetation cover in Land Surface Emissivity (LSE) equation was calculated by using the formula given in equation 10. NDVI is calculated using equation (4).

$$FVC = \frac{NDVI - NDVI_S}{NDVI_V - NDVI_S} \qquad (10)$$

Where,

$NDVI_S$ – NDVI reclassified for soil
$NDVI_V$ – NDVI reclassified for vegetation

3.5 Mean and Difference in LSE Calculation

From the previous part LSE for band 10 and band 11 are calculated seperately are used to calculate mean and difference in LSE. The mean and difference in LSE are calculated by using the Equation 11 and 12 given below.

$$Mean\ LSE = \frac{LSE_{10} + LSE_{11}}{2} \qquad (11)$$

$$Differance\ LSE = LSE_{10} - LSE_{11} \qquad (12)$$

3.6 Final LST Retrieval

The output from the above five steps like mean and Difference in LSE of two bands, Brightness temperature for two bands, Split-Window Co-efficient, LSE retrieval are applied as a input to the final Split-Window equation to retrieve final LST . LST was calculated by applying a structured mathematical algorithm viz., Split Window (SW) algorithm. The SW algorithm proposed in this paper is based on the mathematical structure proposed by (*Jiménez-Muñoz et.al, 2008).* The SW algorithm for LST retrieval is given in Equation 13:

$$LST = TB_{10} + C_1(TB_{10} - TB_{11}) + C_2(TB_{10} - TB_{11})^2 + C_0 + (C_3 + C_4W)(1 - \varepsilon) + (C_5 + C_6W)\Delta\varepsilon \qquad (13)$$

Where, C_0 *to* C_6 are the Split-Window Coefficient Values.

TB_{10} *and* TB_{11} – Brightness temperature of band 10 and band 11 (in Kelvin)

ε – Mean LSE of TIR bands
ω – Atmospheric water vapor content in (g.cm^{-2})
Δ ε – Difference in LSE

4. Results and Discussion

4.1 SC Algorithm

The final LST image (Figure 8), for SC method is given below. The NDVI value for the given image lies between -1 and 0.6095. The emissivity value for image lies between 0.0956 to 0.99. Finally by using Single channel algorithm the temperature of the image lies between 24°C to 42°C.The mean temperature by using Single channel algorithm is 34.5°C. For Single Channel (SC) algorithm the error is approximately 1K-2K. From the final output image it is inferred that the areas with vegetation and water show lesser temperature of 24°C to 30°C. Most of the urban areas in Madurai region show temperature between 31°C to 35°C. The residential areas show less temperature when compared to the open ground without any vegetation and water body. The areas with high temperature are waste lands and open grounds.

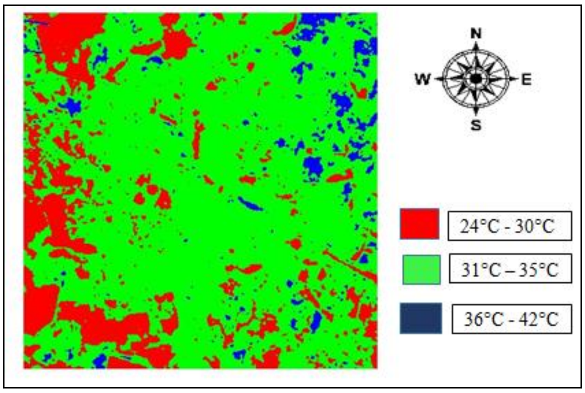

Fig 8: *LST image - SC algorithm*

4.2 SW Algorithm

The final LST image for SW method is shown in Figure 9**.** The NDVI value for the given image lies between -1 and 0.518. The emissivity value for band 10 image lies between 0.96 to 0.9754 and the emissivity value for band 11 image lies between 0.9688 to 0.9803. Finally by using Split Window algorithm the temperature of the image lies between 20°C to 35°C. The mean temperature by using Split-Window algorithm is 27.5°C. The simulation results show that an average error by using this method is less than 1K. From the final output it is inferred that the areas with vegetation and water show less temperature than the urban areas in Madurai region. The temperature of Barren lands and uncultivated lands are higher than the urban areas. The areas with high temperature are waste barren lands

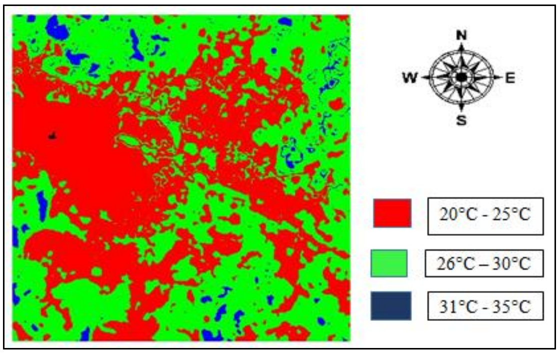

Fig 9: *LST image - SW algorithm*

5. Conclusion

Urbanisation is a greatest threat to all developing countries in the world. This leads to reduction in vegetation cover which are replaced by junks of concrete buildings and asphalt roads. Various researches have proved that increase in population and urban areas leads to lot of environmental issues. Densely developed urban areas are often 2 to 9 degrees Fahrenheit warmer than they would be if left in an undeveloped condition, a phenomenon known as "urban heat island effect"(UHI). Urban Intensity of urban heat island refers to the extent to which the temperature in a local unit inside the urban area differs from that in the surrounding suburban areas. Greater the intensity of urban heat island means more heat is housed inside the city than in the suburb, and a more obvious urban heat island effect. The difference of LST between Urban and urban surrounding has an important impact on the urban climate and environment. UHI is performance of this difference (Wang et.al, 2008). The various land cover types such as dense vegetated areas, barren land and industrial areas, dense built up spaces, water bodies etc., contributes to the variation in temperatures leading to the formation of urban micro heat islands (Amirtham et.al, 2009). This paper has used two methods to retrieve LST of Madurai region. For Single Channel (SC) algorithm the simulation results show an error of approximately 1K-2K. In Split-Window (SW) algorithm the error (reduced because in SW algorithm two TIR bands are used for land surface temperature retrieval. In SW algorithm the simulation results show that the error is less than 1K. From the findings of the study, it is revealed that barren lands, uncultivable land and urban areas experienced high LST and the areas with high vegetation cover and water body experiencing lower LST. The results from both the algorithms show a variance of 5-6^{o}C between urban areas, barren lands and vegetation covers. This clearly indicates the presence of UHI in the city of Madurai, although an extensive validation exercise from in situ measurements of outdoor temperature is required to assess the performance of the two LST algorithms.

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